United States Environmental Protection Agency **Office of Research and Development**

National Exposure Research Laboratory
Research Abstract

Government Performance Results Act (GPRA) Goal 8
Annual Performance Measure 85

Significant Research Findings:

Spatially-Distributed Everglades Mercury Model

Scientific Problem and Policy Issues

The cycling and accumulation of mercury in aquatic food chains in the Everglades initially emerged as an issue with the discovery of elevated concentrations of Hg in largemouth bass in 1989. Although atmospheric deposition is recognized as the predominant source of mercury to the Everglades, the spatial heterogeneity of concentrations of mercury in biota indicates that localized biogeochemical factors play an important role in the mercury loads in aquatic biota. The main scientific problem is to elucidate how atmospheric deposition fluxes result in the observed spatial gradients in total and methyl mercury in water, marsh soil, and biota. In order to evaluate the ecological and human health effects of proposed management and restoration options for the Everglades, The U.S. Environmental Protection Agency (EPA) was interested in describing the interrelationships between anthropogenic disturbances in the Everglades and possible effects on the aquatic mercury cycle.

Research Approach

A process-based simulation model of mercury biogeochemistry and bioaccumulation was linked internally with an empirical phosphorus-vegetation dynamics module and linked externally to a spatially distributed model of water flow and phosphorus dynamics in the Everglades. The Everglades Mercury Cycling Model (E-MCM) is a dynamic model designed to predict the complex and often competing effects of changing mercury loadings, hydrology, and trophic state on mercury dynamics. E-MCM was initially developed as a one box “unit wetland” model that was applied to discrete Everglades sections of particular interest, each including two layers in the water column and three sediment layers. The model simulates elemental, divalent, and methyl mercury in the marsh and methyl mercury bioaccumulated in the food web. Sensitivity analyses with E-MCM indicated that the important external parameters controlling mercury fate include hydrologic flows and depths, concentrations of total phosphorus and concomitant changes in macrophyte and periphyton production, turnover, and decomposition. Thus, in order to use E-MCM to examine the scientific and management questions, E-MCM was linked to an external trophic state model that could predict changes in nutrient concentrations and the concomitant effects on trophic state, including associated variables such as carbon turnover rates, detrital fluxes and sedimentation, etc. Finally, the E-MCM spatial linkage was extended to accommodate a spatial network that could include the entire Everglades.

The Everglades Phosphorus and Hydrology (EPH) model was chosen as the underlying platform to predict hydrologic and nutrient dynamics across the Everglades. In order to relate the effects of changing phosphorus dynamics on mercury cycling in the Everglades, changes in nutrient concentrations predicted by EPH were translated into changes in trophic state and related variables, based on empirical relationships between total water column phosphorus, march vegetation, and sedimentation (peat accretion) rates.

Results and Impact

This work documents the first "proof-of-concept" stage of linking a unit process mercury biogeochemistry model to a spatially-distributed flow and nutrient model. The focus for this stage is the application of the linked models to Water Conservation 2A, a region marked by a profound gradient in total phosphorus concentrations across the system, and by changes in the relative importance of surface vs. atmospheric inputs of water as one moves from the inflow control structures towards the interior and outflow control structures of the system.

Preliminary results with the spatially distributed E-MCM suggest that spatial dynamics of Hg accumulation are influenced by the complex interplay of a number of relationships, including (1) the relationship between trophic state and particle dynamics, which influence sedimentary Hg concentrations directly and also influence methylation rates; and (2) water depth and methyl Hg dynamics in the water column. This latter relationship reflects the fact that for most cells methyl Hg is largely produced *in situ*, rather than imported from upstream cells. Interestingly, depending upon the cell, differing temporal dynamics for fish tissue concentrations were predicted.

This linked modeling system should be able to describe mercury fate more realistically than earlier distributed screening models or point-based process models. This should lead to more confident analyses and evaluations of management alternatives in the Everglades.

Research Collaboration and Research Products

A general dynamic version of MCM was initially modified and extended to the Everglades under contract to the EPA to include features specific to the Everglades and not previously considered by MCM. E-MCM has recently been further modified to improve its conceptual representation of important biogeochemical processes in the Everglades under contract to the Florida Department of Environmental Protection and co-funded by the South Florida Water Management District.

Future Research

The next logical step is to extend the application of this linked modeling system to the entire Everglades system and test its predictions for the period of record. In addition, further process experimentation would help render this model more predictive. Sulfate and sulfide concentrations also are believed to be important external parameters influencing Hg cycling in the Everglades, but the ability to predict changing sulfate and porewater sulfide concentrations and resultant changes in Hg methylation and cycling in response to changing external inputs to the system has yet to be fully developed. In the future, it would be useful to utilize more predictive relationships between phosphorus levels and vegetation response, such as are being developed by the South Florida Water Management District in the Everglades Landscape Model.

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